MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2017/2018

EME2066 –MEASUREMENT AND INSTRUMENTATION

(ME)

14 OCTOBER 2017
02.30 p.m. - 04.30 p.m.
(2 Hours) – OPEN BOOK

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 5 pages including cover page with 4 Questions only.
2. Attempt **ALL** questions. All questions carry equal marks.The distribution of the marks for parts of each question is shown.
3. Please write all your answers in the Answer Booklet provided.
4. This is an **OPEN BOOK** examination. The book allowed is, " Experimental Methods for Engineers" by J.P.HOLMAN, McGraw Hill Publication, 8th Edition (***only printed book is allowed***).
5. Please refer to the above book for any additional data required.

QUESTION 1

(a) A temperature measurement device is believed to behave as a first-order system with a rise time of 0.2 s. At time zero the device is at a temperature of 45°C. What temperature will be indicated by the device 0.1 s after it is suddenly exposed to a temperature of 100 °C? Assume that the rise time remains constant.

[9 marks]

(b) A resistance arrangement of 50 Ω is desired. Two resistances of 100.0 ± 0.1 Ω and two resistances of 25.0 ± 0.02 Ω are available. Which should be used, a series arrangement with the 25-Ω resistors or a parallel arrangement with the 100-Ω resistors? Calculate the uncertainty for each arrangement.

[8 marks]

(c) A Wheatstone bridge circuit has resistance arms of 400 Ω, 40 Ω, 602 Ω, and 6000 Ω taken sequentially around the bridge. The galvanometer has a resistance of 110 Ω and is connected between the junction of the 40 Ω and 602 Ω resistors to the junction of the 400 Ω and 6000 Ω resistors. The battery has an emf of 3 V and negligible internal resistance. Calculate the voltage across the galvanometer and the galvanometer current.

[8 marks]

Continued ...

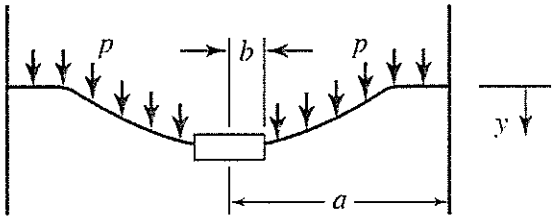
QUESTION 2

(a) A U-tube-type manometer uses mercury (with density ρ_m) as the sensing fluid for measuring differential pressure across an orifice which has water (with density ρ_f) as the flow medium. The difference in mercury column heights is measured as 45.2 ± 0.1 cm. Calculate the difference in pressure and its uncertainty in kPa if the apparatus temperature is 20 °C. (Hint: get ρ_m from table A.4 and ρ_f from table A.8)

[9 marks]

(b) A diaphragm pressure gage is constructed as in Fig. 2b, with a = 2.5 cm, b = 0.3 cm, and t = 0.122 cm. The material is spring steel (E = 200 GN/m^2, μ = 0.3). What pressure, in pascals, will be necessary to cause a deflection of 0.04 cm?

[4 marks]



$$y_{max} = \frac{3p(1-\mu^2)}{16Et^3}\left[a^4 + 3b^4 - 4a^2b^2\ln(a/b) + \frac{16a^2b^2}{a^2-b^2}\left(\ln\frac{a}{b}\right)^2\right]$$

Fig. 2b A diaphragm pressure gage

(c) Calculate the dynamic pressure measured by a Pitot tube in a flow stream of water at 20 °C moving at a velocity of 3 m/s.

[3 marks]

(d) An orifice is to be used to indicate the flow rate of water in a 3.175-cm-diameter line. The orifice diameter is 1.25 cm. What pressure reading will be experienced on the orifice for a line-flow velocity of 3.0 m/s? What would be the flow rate for a pressure reading of twice this value? Kinematic viscosity is 0.1 x 10^{-5} m^2/s. (hint: the flow coefficient should be obtained from relevant chart).

[9 marks]

Continued ...

QUESTION 3

(a) An RTD has a linear characteristic in temperature. given by:

$$R = R_0(1 + \alpha (T - T_0))$$

where α at 20 °C = 0.004/°C. If R_0 = 106 Ω at T_0 = 20 °C, find the resistance at 25 °C. The RTD is used in a bridge circuit like that shown in Fig. 3a. If $R1 = R2 = R3$ = 100 Ω and the supply voltage is 10.0 V, calculate the output voltage, ΔV. Calculate the voltage the detector must be able to resolve in order to resolve a change of 1.0 °C

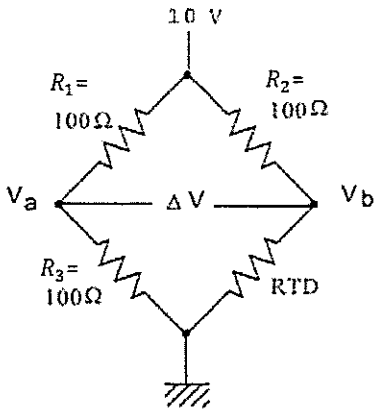


Fig. 3a Bridge circuit of RTD

[9 marks]

(b) A chromel-alumel thermocouple is exposed to a temperature of 1560 °F. The potentiometer is used as the cold junction, and its temperature is estimated to be 83 °F. Calculate the emf indicated by the potentiometer.

[4 marks]

(c) A radiant energy measurement is made to determine the temperature of a hot block of metal. The emitted energy from the surface of the metal is measured as 28 ± 0.4 kW/m^2 and the surface emissivity is estimated as ε = 0.90 ± 0.05. Calculate the surface temperature of the metal and estimate the uncertainty.

[6 marks]

(d) The thermal conductivity of an insulating material is to be determined using a guarded hot-plate apparatus. A 30 × 30-cm sample is used, and the approximate thermal conductivity is about 1.7 W/m°C. A differential-thermocouple arrangement is used to measure the temperature drop across the sample with an uncertainty of ± 0.3 °C. A heat input of 5 kW ± 1% is supplied, with a resulting temperature drop of 55 °C. The sample thickness is 2.0 mm. What is the thermal conductivity and its uncertainty, assuming no heat losses and that the sample dimensions are known exactly?

[6 marks]

Continued ...

QUESTION 4

(a) To measure the force, P, applied to the cantilever beam, four strain gages of a bridge are arranged in series such that all the gages are active as shown in Fig. 4a1. The beam specifications are: $b = 1$ mm, $a = 10$ mm and Young's modulus $E = 206$ GPa. Force P is applied at a distance $x = 50$ mm from the strain gages. The force P, in this case, can be expressed as $P = \dfrac{\sigma a b^2}{6x}$ where $\sigma = \varepsilon E$ and ε is the strain. The applied bridge circuit is shown in Fig. 4a2. The values for resistors are $R_1 = R_2 = R_3 = R_4 = 120\Omega$, the Gage Factor = 2.4 and the input voltage $V_s = 9$V. If the output voltage, $V_o = V_a - V_b$, from the bridge is 20 mV, calculate the force applied.

[19 marks]

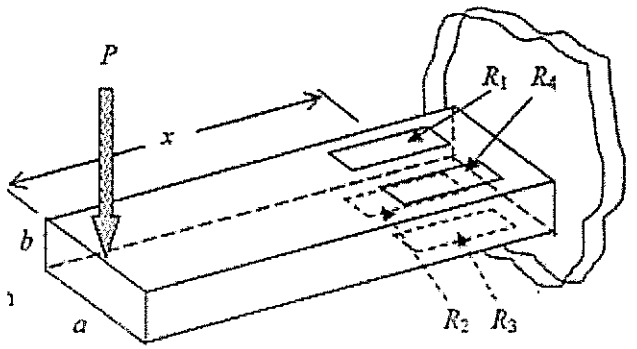


Fig. 4a1 A cantilever beam with 4 active starin gages

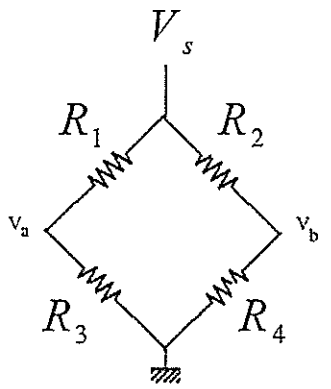


Fig. 4a2 A bridge circuit

(b) A certain automotive engine is reported to produce a torque of 500 Nm at 2500 rpm. What power dynamometer would be necessary to test this engine? Express in kilowatts.

[6 marks]

End of Paper